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F00 BIT OPTIMIZATION PROJECT

Meeting Schedule

Date: 5/22/98 Time: 1.30 PM Venue: Conference Room, E 159B

Agenda

1. Introduction by S.J. Huang.
2. IDEAS program validation and development.
3. Analysis of current F00 bit design.
4. Benchmarking of F00 bit with respect to F05 and FDS bits. ✓
5. Development of F00 bit design.
   - Preliminary Insert Designs and their comparative analysis. ✓
   - Variation of Insert counts and consequent results. ✓
   - Modification of bit cutting structure with results.
   - Discussion of results followed by recommendations for future development.

1 F00 BIT OPTIMIZATION PROJECT

SMITH INTERNATIONAL, INC.

2 Agenda

- IDEAS PROGRAM VALIDATION AND DEVELOPMENT
- ANALYSIS AND BENCHMARKING OF CURRENT F00 BIT DESIGN WITH RESPECT TO F05 AND FDS BITS
- DEVELOPMENT OF THE F00 BIT
- NEXT STEP
- REAL TIME CHALLENGES
- SUPPLEMENTARY WORK

3 Program validation and development

- Duplicating field results
  - W.O.B.= 7-13 kdAN
  - R.P.M.=80-240 rpm
  - R.O.P.=35 m/hr
- IDEAS Parameters & Results
  - Rock Types
    - Ductile
    - Brittle
  - W.O.B.=10,000 kg-f
  - R.P.M.=140 rpm
  - R.O.P.=24-28 m/hr
- Verifying performance trends

4 Analysis and Benchmarking of current F00 bit design

- Identifying Key Performance Parameters
  - R.O.P.
  - Coverage
- Comparison with FDS and F05 bit designs

5 The Target

- DUCTILE ROCK
  - R.O.P.=24.82 m/hr
  - COVERAGE=56.02 %
- BRITTLE ROCK
  - R.O.P.=26.95 m/hr
  - COVERAGE-39.59 %

6 Development of F00 bit design

- Insert shapes
  - 10 different shapes compared
- Row counts
  - Adding and subtracting inserts from all rows
- Cutting structure modifications
  - Improving core design

7 Selection of Inserts

- CONVENTIONAL DESIGNS
  - CHISEL
  - VECTOR
  - CONICAL
- EXPERIMENTAL DESIGNS
  - MAVERICK
  - DURA
  - COBRA

8 Surpassing The Target in Ductile Rock

- INSERT SHAPES
  - R.O.P. = 12% Increase [Vector]
  - COVERAGE = 4% Increase [Vector]
- ROW COUNTS
  - R.O.P. = 16% Increase [-1 Insert on each row]
  - COVERAGE = 5% Increase [-1 Insert on each row]

9 Achieving The Goal in Brittle Rock

- INSERT SHAPES
  - R.O.P. = 62% Increase [Vector] (Coverage being 5% lower)
  - COVERAGE = 5% Increase [Concept] (R.O.P. being 9% lower)
- ROW COUNTS
  - R.O.P. = 15% Increase [+1 Insert on each row]
  - COVERAGE = 14% Increase [+2 Inserts on each row]

10 Next Step

- Combination/selection of optimized insert shape for drive rows
- Optimize cutting structure
  - Bottom hole profile
  - Individual Row counts
  - Skip pitches

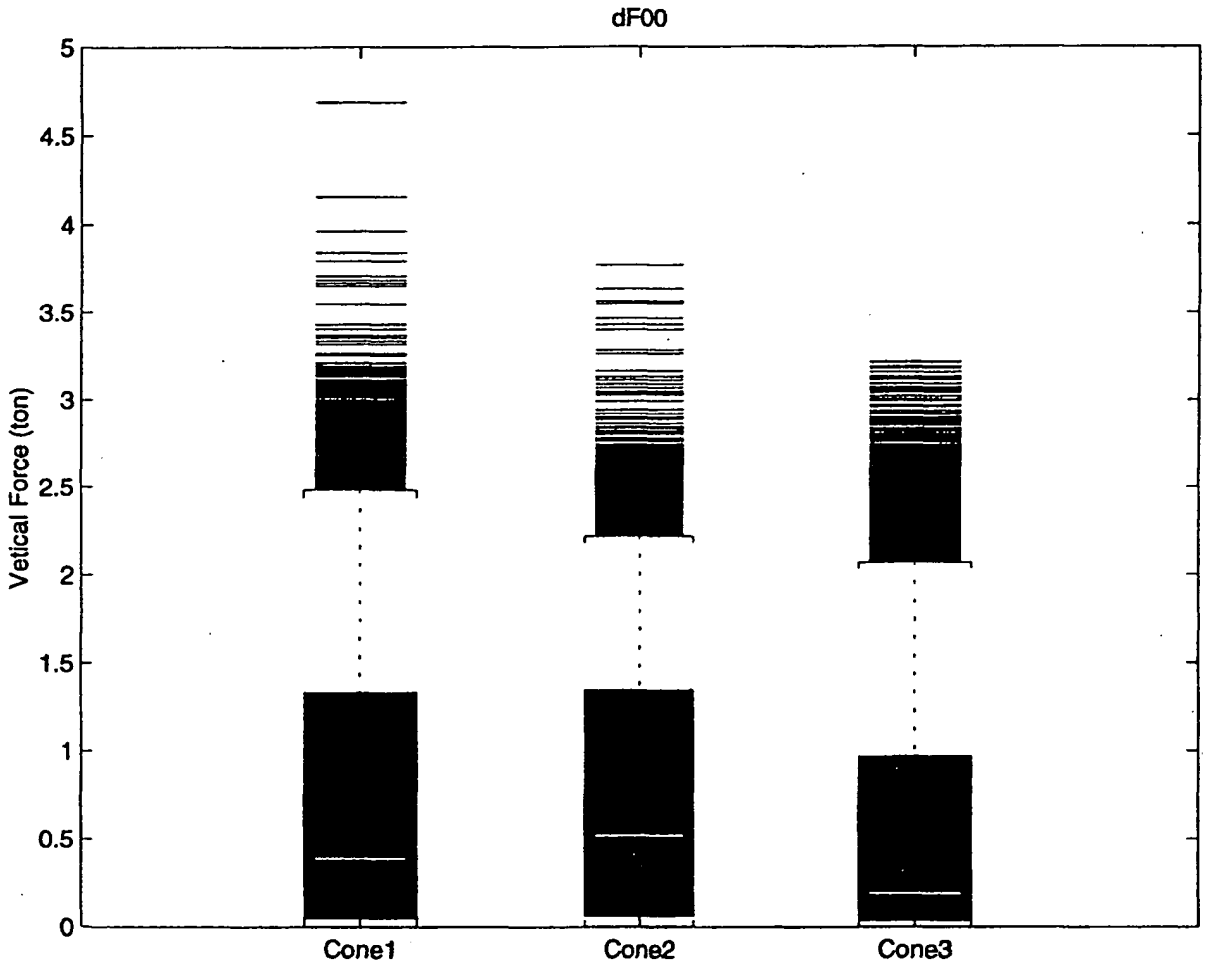
- Force Analysis
  - Balancing cutting structure based on forces
- Study of gage area

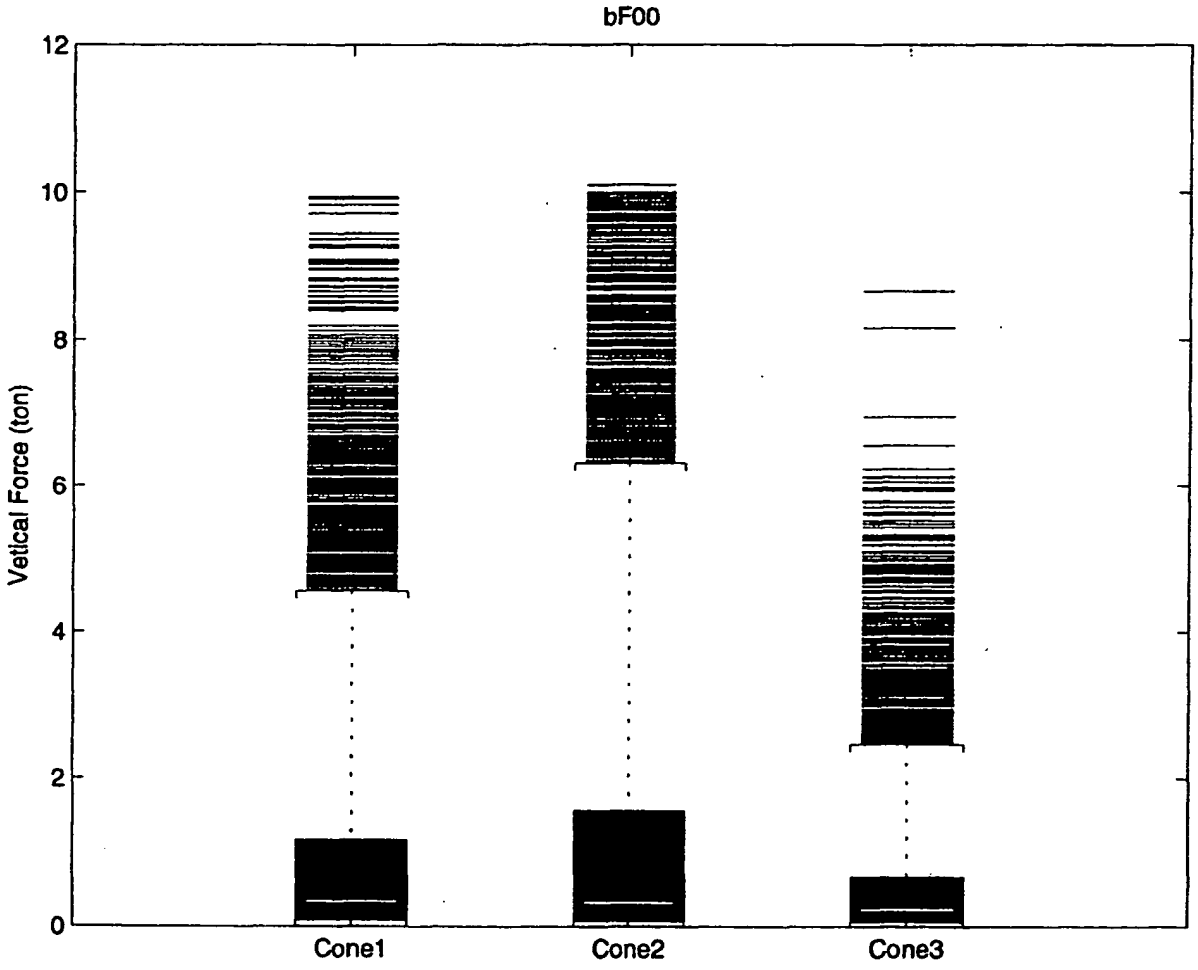
11 Real Time Challenges

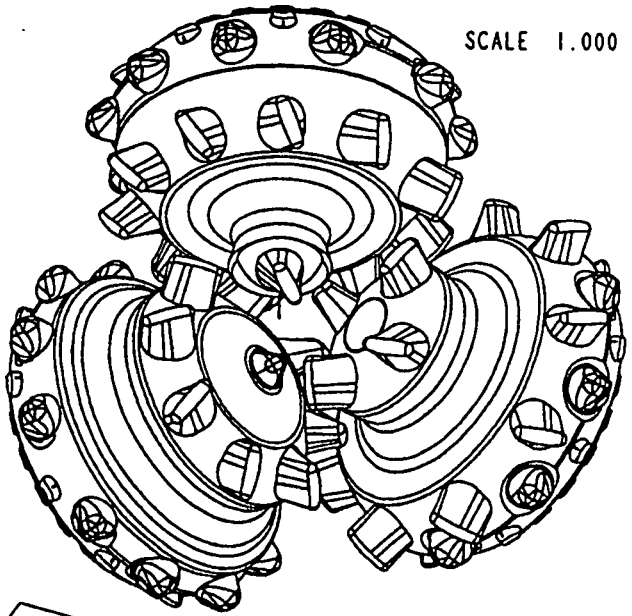
- Insert Retention
  - Iceman
  - Trucut
- Insert Rotation
  - Iceman
  - Off-gage
- Insert Breakage
  - Iceman
  - Off-gage
  - Trucut
- Cone Peeling

12 Supplementary Work

- IDEAS program development
- Lab testing
  - Single insert indentation tests
- Insert manufacture (Including RTW in the design loop)
  - Injection Molding
  - Punch and die process
- Patent Issues


dF00
Vetical Force (ton)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Cone1
Cone2
Cone3


bF00
Vetical Force (ton)
12
10
8
6
4
2
0
Cone1
Cone2
Cone3



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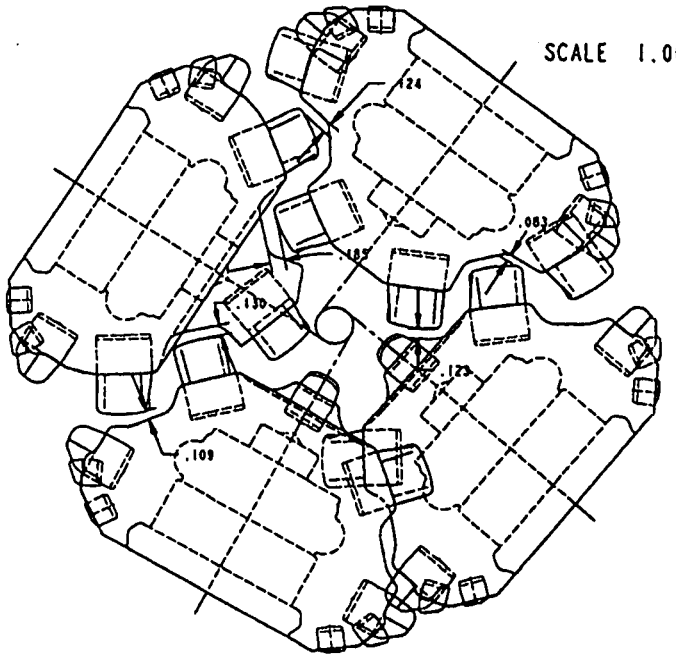

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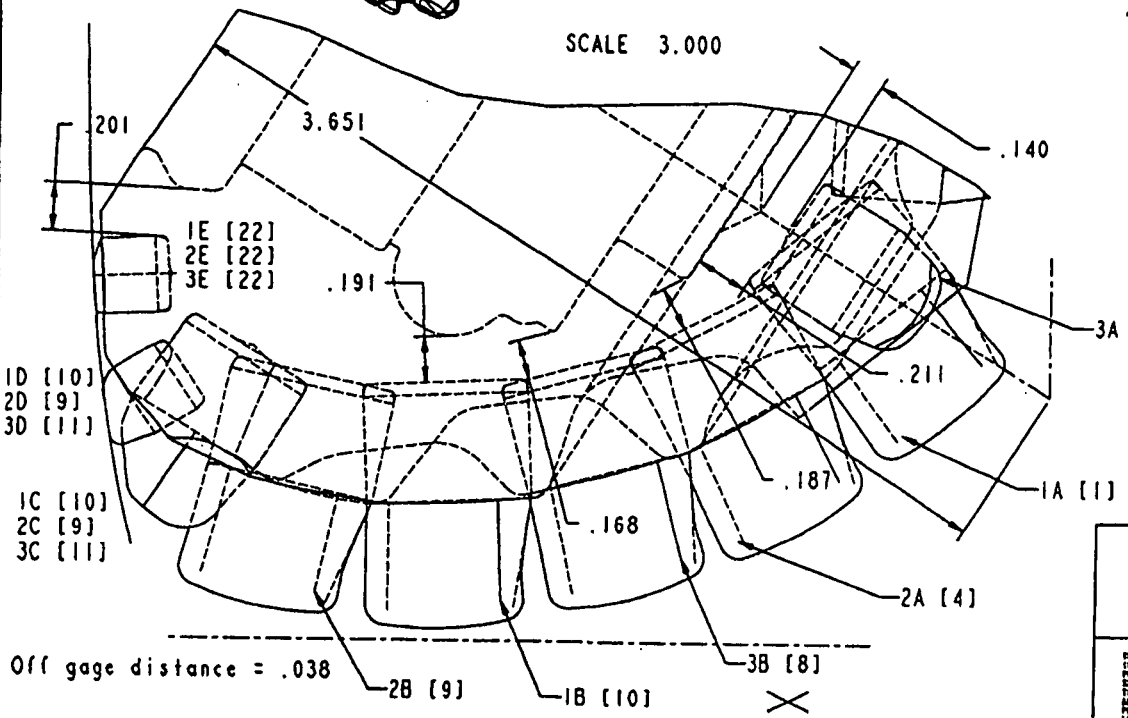

NAME		ORCA-BIT								
	ROW	INSERT	COUNT	PITCH	TYPE	DIA/WID	LENGTH	EXT	GRIP	GRADE
CONE1										
	A	ORCA3	1	-	ORCA	.5625	.675	.510	.450	614
	B	ORCA3	10	10.42	ORCA	.5625	.675	.510	.450	614
	C	R_GAGE	10	10.42	R_GAGE	.5625		.370	.410	510
	D	0018626	10	10.42	SLC	.3125		.160	.240	406
	E	0018134	22	-	SLC	.3125		.040	.288	406
CONE2										
	A	ORCA1	4	-	ORCA	.5625	.675	.510	.450	614
	B	ORCA1	9	-	ORCA	.5625	.675	.510	.450	614
	C	R_GAGE	9	-	R_GAGE	.5625		.370	.410	510
	D	0018626	9	-	SLC	.3125		.160	.240	406
	E	0018134	22	-	SLC	.3125		.040	.288	406
CONE3										
	A	0020323	1	-	RBC	.500		.300	.360	614
	B	ORCA1	8	-	ORCA	.5625	.675	.510	.450	614
	C	R_GAGE	11	11.45	R_GAGE	.5625		.370	.410	510
	D	0018626	11	11.45	SLC	.3125		.160	.240	406
	E	0018134	22	11.45	SLC	.3125		.040	.288	406

PART NUMBER: LT077-ORCA -

UNLESS OTHERWISE SPECIFIED TOLERANCES ARE AS FOLLOWS:
DECIMALS: X ±.01, X.X ±.01, X.XX ±.005, X.XXX ±.0025
ANGULAR: ±0.5°
FRACTIONAL: 1/64
FILLETS: .030
REMOVE ALL BURRS AND BREAK SHARP CORNERS .005 - .010

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SMITH TOOL
Division of Smith International Inc.

077 FOO BIT LAYOUT
ORCA INSERTS

SCALE: 0.3	MODEL NAME: LT077-ORCA		SHEET: 1 OF 1
SIZE: C	DRAWN: AS	DATE: 4-Jun-98	DRAWING NO.: DLT077-ORCA	REV: -

IDEAS Calculation Summary
Project: /users/fa8297/ideas/orca-bit
Diameter of Bit: 7.87 (in) [200 (mm)]
Weight on Bit: 22046 (lbf) [10000 (kgf)]
Revolutions per minute: 140 (rpm)
Revolutions of Simulated: 40 (rev)
Hardness coefficient of Rock: 14504 (lbf/in2) [100.0 (Mpa)]
The Critical Contact Depth of Rock: 7.874 [in] [200.0 (mm)]
Anti-breakage Factor of Rock: 1000.000 (Mpa/mm)
Borehole area: 48.707 (sq.in)

Rev.	CutArea (sq.in)	Coverage %
1	20.94	43.00
2	27.54	56.53
3	26.24	53.88
4	25.16	51.66
5	26.82	55.06
6	31.18	64.02
7	26.00	53.39
8	27.28	56.01
9	30.34	62.30
10	28.54	58.60
11	26.23	53.86
12	25.48	52.31
13	27.01	55.45
14	31.35	64.36
15	22.71	46.62
16	28.75	59.03
17	26.37	54.15
18	28.02	57.53
19	28.74	59.00
20	30.89	63.42
21	26.36	54.13
22	26.43	54.26
23	29.97	61.52
24	24.78	50.88
25	28.05	57.58
26	29.69	60.96
27	23.68	48.63
28	26.64	54.69
29	30.10	61.79
30	22.58	46.36
31	28.48	58.47
32	26.57	54.55
33	27.83	57.13
34	24.03	49.34
35	32.74	67.22
36	29.79	61.16
37	24.48	50.26
38	26.74	54.90
39	27.40	56.25
40	26.16	53.71

Average of Coverage for Bit: 55.85 %
Average of Coverage for Each Row:

Cone	Row	Rmin (in)	Rmax (in)	C.Avr (sq.in)	CovI %	CovA %
1	1	3.827	3.937	0.005	0.17	0.01
1	2	3.488	3.937	0.488	4.66	1.00
1	3	3.047	3.936	1.986	10.19	4.08
1	4	1.898	3.074	6.412	34.92	13.17
1	5	-0.020	1.007	0.460	14.46	0.95
2	1	3.802	3.937	0.005	0.14	0.01
2	2	3.507	3.937	0.341	3.39	0.70
2	3	3.013	3.936	1.680	8.34	3.45
2	4	2.544	3.768	6.231	25.67	12.79
2	5	0.537	1.651	2.506	32.75	5.15

3	1	3.807	3.937	0.005	0.15	0.01
3	2	3.486	3.937	0.465	4.42	0.95
3	3	3.008	3.937	2.215	10.92	4.55
3	4	1.225	2.351	4.360	34.47	8.95
3	5	0.352	0.738	0.029	2.23	0.06

Max Penetration Depth 0.437 (ft) [133 (mm)]
Average of ROP 85.38 (ft/h) [26.02 (m/h)]
Ratio of Cone Rotary Speed to Bit:

Cone	Ratio
1	1.1950
2	1.2750
3	1.1320

Scraping Brittle File Size 19248 (bytes)
Vertical Brittle File Size 19200 (bytes)
Shell Contacted Times 255 (times)
Contact Percentage of Shell to Rock 5.3125 %

	f_r	f_c	F_2
~~Cone 1~~			
Cone 1	2.5/2.6	.7	3.6/3.7
Cone 2	3.0/3.0	.7	4.2/4.5
Cone 3	2.0/1.7	.3	2.6/2.5
Cone 1 Below	1.8/1.6	.2	2.7/2.5
Cone 3 Below	1.6/1.5	.2	2.0/2.2